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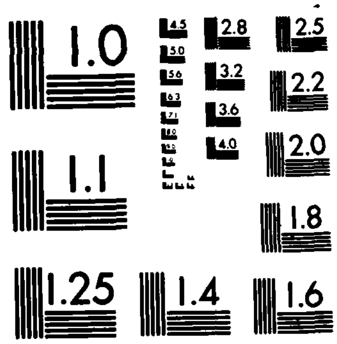

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INTERIM REPORT

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ARMY PROCUREMENT RESEARCH OFFICE

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FINAL

CONTRACTOR PRODUCTIVITY MEASUREMENT PRACTICES

OCTOBER 1983

U. S. ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY
ARMY PROCUREMENT RESEARCH OFFICE
FORT LEE, VIRGINIA 23801

APRO 83-01
Interim Report

CONTRACTOR PRODUCTIVITY MEASUREMENT PRACTICES

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The pronouns "he," "his," and "him," when used in this publication, represent both the masculine and feminine genders unless otherwise specifically stated.

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EXECUTIVE SUMMARY

A. BACKGROUND. The cost of producing weapon systems with the current defense industrial base continues to escalate. In addition, the deteriorated condition of the base has prompted increased concern over its capability to respond to mobilization requirements. The recognition of these problems led to the initiation of a DOD Industrial Modernization Incentives Program (IMIP) which targets industry through incentives to substantially increase its capital investments with its own financing in modern technology, plant and equipment for defense work. A requisite for productivity rewards from these incentives is the ability to accurately measure and track a contractor's productivity gains.

B. STUDY OBJECTIVES. The objective of this study is to develop and test measurement systems which (1) are designed to complement IMIP by providing a productivity measurement and tracking system and, (2) may provide a basis for contract incentives to motivate contractors to improve their productivity through methods changes, management improvements and other means in addition to capital investment.

C. STUDY APPROACH. All military services are participating in this DOD study. Defense contractors are also involved in system development through a survey of contractor productivity measurement practices. The general study approach is to conduct a literature search and thorough investigation of productivity measurement theory. The theory investigation is then complemented with a survey of contractor productivity measurement practices. From an analysis of the literature and survey responses, productivity measurement methodologies will be synthesized. The proposed methodologies will be tested, and if warranted, an implementation guide supporting the IMIP will be prepared.

D. SUMMARY AND RECOMMENDATIONS. This interim report describes the results of a survey of contractor productivity measurement practices and the productivity measurement systems identified to date. Contractors responding to the survey ranked productivity fifth in importance as a performance evaluation factor after profitability, effectiveness, quality, and efficiency. There was no evidence of a total factor productivity measurement system implemented by the survey respondents, although some attempts were being made to develop such. Production cost visibility varied widely among the survey respondents, but all could provide direct labor and material costs through work center tracking. Unfortunately, direct costs constitute a small and decreasing percentage of total cost, and therefore are becoming less useful as the sole basis for productivity measurement. The most popular productivity related indices being tracked were value added/employee and a comparison of standard hours to actual hours. It appeared that investments were mostly for competitive and technological reasons rather than simply for cost reduction on a current contract.

Several productivity measurement systems were identified as having potential application in IMIP. Those that should be tested include the Mult-Factor Productivity Measurement Model (MPMM), the Product-Oriented Total Productivity Measurement (PTPM) model, and the Cost Benefit Analysis/Cost Benefit Tracking (CBA/T) methodology.

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CHAPTER I

INTRODUCTION

A. BACKGROUND/PROBLEM.

As shown in recent APRO studies and other investigations, productivity in the defense industry can be and needs to be improved. The cost of producing weapon systems with the current base continues to escalate. In addition, the deteriorated condition of the defense industrial base has prompted increased concern over its capability to respond to mobilization requirements. Productivity improvements are required before solutions to these persistent problems can be realisitically expected.

Many factors have contributed to the declining productivity growth within the defense industry. The general economic environment in the US has not provided the stimulus required for modernization investments. Inflationary periods permit passing on price increases due to inefficiencies as well as those due to increased productivity. High interest rates and federal tax policies can further inhibit capital investments. Also, excessive short-run thinking in business decisions has neglected productivity where investments typically bring mid to long-run paybacks.

Initiative Number 5 of the Acquisition Improvement Program was directed at encouraging capital investment to enhance productivity. In addition to contract financing improvements, several productivity actions have emanated from the spirit of the Acquisition Improvement Program. A newly established Industrial Productivity Directorate within OSD has the responsibility of providing leadership in the productivity area. They serve as a focal point, facilitator, and advocate on productivity issues. Also, a DOD Industrial Modernization Incentives Program (IMIP) was initiated which targets industry through incentives to substantially increase its capital investments with its own financing in modern technology, plant and equipment for defense work. Such investments will contribute to productivity growth, reductions in the cost of producing end items, and an improved industrial base.

A requisite for productivity rewards is the ability to accurately measure and track a contractor's productivity gains. At present, contractor efficiency and productivity cannot be readily measured and related to a contract. A practical method of measuring productivity and effecting rewards must be developed to stimulate improved productivity. Development of a methodology for productivity measurement is of importance if certain types of incentives are to be employed. This effort will support the IMIP.

B. STUDY SCOPE.

This study is looking at ways of measuring contractor productivity and relationships between possible measurement techniques and associated potential productivity incentives. Alternatives for measuring productivity, the type of productivity data needed, the type of data currently available, and the degree to which the data would be verifiable and suitable as a basis for appropriate contract incentives are being explored. The study will also look at proposed incentives from the standpoint of productivity related information needed to support the incentives.

C. STUDY OBJECTIVE.

The development of a productivity measurement methodology constitutes a major effort addressing such issues as specific definitions of contractor productivity and its measurement. The objective of this study is to develop and test measurement systems which (1) are designed to complement IMIP by providing a productivity measurement and tracking system and, (2) may provide a basis for contract incentives to motivate contractors to improve their productivity through methods changes, management improvements and other means in addition to capital investment. Specific subobjectives proposed to accomplish this are:

1. Develop specific definitions of contractor productivity appropriate for the products concerned and the contracts involved.

2. Design measurement techniques that allow for establishing a baseline, tracking performance, and showing auditable results.

3. Relate these measurement techniques to incentives and reward mechanisms.

4. Synthesize the definitions, measurement techniques and reward mechanisms.

5. Test the proposed methodology on representative contracts and contractors to determine the suitability for DOD implementation.

6. Based upon the test results, recommend DOD policy and procedure coverage, as appropriate.

D. STUDY APPROACH.

A study that addresses defense contractor productivity measurement is a high-risk effort in terms of probability of success, but it has tremendous potential benefitis to be shared by all. To reduce the risks and improve the probability of success, top-level management within DOD and each of the military services has supported this effort. To improve the chances for system acceptance and to establish credibility throughout the defense community, DOD and the defense contractors have been involved in system development.

The study team for this DOD effort supporting IMIP included representatives from the following organizations: Defense Systems Management College (DMSC), Army Procurement Research Office (APRO), Naval Office for Acquisition Research

(NOAR) and Air Force Business Research Mangement Center (AFBRMC). The representatives shared the responsibility for completing the following actions to meet the study objectives:

1. Review pertinent literature and current policy relating to productivity.

2. Design a contractor survey and distribute it to defense contractors through an industry association.

3. Analyze literature and survey responses.

4. Contact Government personnel in those functional areas impacting productivity measurement for insights into relationships.

5. Visit selected contractors responding to the survey for detailed follow-up discussions.

6. Synthesize proposed productivity measurement methodology based upon analyses and findings.

7. Design test plan.

8. Conduct test.

9. If warranted, develop implementation guide.

Not all of the above actions have been completed. Chapter II of this interim report describes the study results to date, primarily results from the contractor survey and follow-on discussions. Chapter III lists five productivity measurement approaches identified during this initial research as having potential application for IMIP. A final study report will include the results of the investigation of productivity measurement theory and propose additional methodologies to be used.

CHAPTER II

CONTRACTOR PRODUCTIVITY MEASUREMENT PRACTICES

A. INTRODUCTION.

A requisite for productivity rewards is the ability to accurately measure and track a contractor's productivity gains. To be useful to the IMIP, a measurement methodology must not only be based on sound theory but also be implementable. Therefore, an examination of productivity measurement practices is a necessary complement to an investigation of productivity measurement theory.

Since Defense contractors have always measured their productivity, directly or indirectly, they are an important source of information [illegible] this study. Their experiences are useful in understanding both what is currently being practiced and what has been tried with varying success. A written survey was used to contact a large sample of defense contractors. The survey not only helped identify current practices but also allowed defense contractors an opportunity to participate in an effort that could eventually affect them. This was considered important to a successful implementation of any proposed methodologies. The National Security Industrial Association (NSIA) was solicited and agreed to participate in a survey of some of its member companies.

B. SURVEY DESCRIPTION.

The primary purpose of the survey was to obtain information about productivity measurement methodologies currently employed by defense contractors. It also opened doors for follow-up discussions by asking for points-of-contact. The survey was not intended to provide an elaborate description or classification of current practices. A copy of the survey and NSIA cover letter is provided in Appendix A.

The survey was sent to 92 different contractor locations. Figure 1 lists the 21 respondents to the survey.

1. Remington Arms - Bridgeport, CT
2. AVCO - Bridgeport, CT
3. Sperry - Waterbury, CT
4. United Technologies - Hartford, CT
5. EG&G Sealog - Warwick, RI
6. Hazeltine - Greenlawn, NY
7. Westinghouse - Columbia, MD
8. Western Electric - Burlington, NC
9. Martin Orlando - Orlando, FL
10. Sparton Corp - Deleon Springs, FL
11. Harris Corp. - Melbourne, FL
12. Northrop Corp. - Los Angeles, CA
13. Rockwell Int'l - Canoga Park, CA
14. McDonald-Douglas - Huntington Beach, CA
15. Ford Aerospace - Newport Beach, CA
16. Ball Aerospace - Boulder, CO
17. Ingalls Shipbuilding - Pascagoula, MS
18. Magnavox - Ft. Wayne, IN
19. Goodyear Aerospace - Akron, OH
20. Honeywell - Edina, MN
21. Anonymous

FIGURE 1. CONTRACTORS RESPONDING TO SURVEY

Follow-up discussions were then held with 14 of those that responded. The number responding was less than desired but adequate to gain an understanding of current practices. The relatively low response rate can be attributed to a general reluctance to participate in any survey and, perhaps, inattention to productivity measurement concepts per se in the defense community prior to the IMIP. Even for those contractors responding, productivity factors were ranked low (usually fifth) relative to other measures of organizational performance asked for in the survey (see Figure 2).

C. SURVEY RESPONSES.

1. General Information. All commodity markets were represented by the responding contractors with electronics and communications equipment being the

dominant market. The contractors involvement as prime, subcontractor or both was roughly balanced among those three choices. The dollar value of their defense contracts during their latest accounting year ranged from $.6M to $4.3B and averaged roughly $500.M. The contractors worked predominantly for the Navy, but all services were represented by the respondents.

2. Performance Evaluation. Question B.1 (shown below) of the survey asked contractors to rank their measures of organizational performance.

> B. PERFORMANCE EVALUATION (at profit center level or above):
>
> 1. Which of the following factors do you use to measure organizational performance within your company? (Indicate order of relative importance to your company, e.g., 1, 2, 3 . . .)
>
> _____ (a) Effectiveness (i.e., accomplishing the right goals or objectives considering timeliness, quantity, and quality)
>
> _____ (b) Efficiency (i.e., ratio of resources expected to be consumed on goal achievement to resources actually consumed)
>
> _____ (c) Quality (i.e., conformance to specifications)
>
> _____ (d) Profitability (i.e., comparison of revenues to costs)
>
> _____ (e) Productivity (i.e., ratio of output to input)
>
> _____ (f) Quality of Working Life (i.e., personnel response to living and working in organization)
>
> _____ (g) Innovation (i.e., introducing new ideas, processes, or products)
>
> _____ (h) Other - (Please specify) ____________________

Figure 2 shows the contractor rankings of these performance evaluation factors. Profitablility was consistently ranked most important by the respondents. Effectiveness and quality were ranked next, respectively, in importance. Productivity, when used, was usually ranked fifth.

PERFORMANCE FACTOR	CONTRACTOR A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
a. Effectiveness	2	3	1	1	3	3	4	1	2	7	1	3	2	4	2	2	1		2
b. Efficiency			3	2		2	5		3	4	4	5	5	5	7	3	3	2	1
c. Quality	4	2	2	2	2		3	3	4	2	3	6	4	2	4	4	2	3	3
d. Profitability	1	1	4	2	1	1	1	2	1	1	2	1	1	1	1	1	5	1	4
e. Productivity	5		5	2		5	6	4	5	3	5	7	3	3	3	5	6		
f. QOWL	6		6	2		6		5		6		4	6	7	5	7	7		6
g. Innovation	3	5	7	2		4	2			5		2	7	6	6	6	4		5
h. Other		4		1	4										8				

FIGURE 2. CONTRACTOR RANKINGS OF PERFORMANCE EVALUATION FACTORS

(Note: The contractor order here has no relationship to the Figure 1 list.)

The only problems identified by the respondents using the above performance factors were:

a. performance measures did not connect with productivity

b. short term was wrong emphasis

c. comparisons between time periods can be influenced by extraneous factors foreign to what is being measured.

3. Productivity Measurement. The productivity measures used by defense contractors varied according to the organizational level being measured. For example, a value added type of index such as value added/employee was frequently used at the firm level. Efficiency measures such as the ratio of standard time/actual time were also used by some to judge productivity at the firm level. Other firm level indicators used included value added/capital, sales/assets, profit/employees, and direct employees/indirect employees.

Although the efficiency ratio of standard time/actual time was used on occasion to judge firm or factor productivity, it was more frequently used at the department or shop level. Generally at this level performance ratios such as inspectors/production workers or units scheduled/units produced were used to measure productivity. Physical units of production were also compared to various labor and capital inputs at this level for true productivity measurement. These include, for example, purchase orders/and engineering change orders/engineer.

Subordinate activites or work centers frequently compared some specific output to labor input. Examples at this level include cables/labor hour or printed circuit boards produced/labor hour. Comparison of standard hours to actual hours for work performed was also popular at the work center level.

Appendix B contains an extensive list of various performance ratios used by one contractor. Using the strict definition of productivity as output/input, not all are productivity measurements; however, they are good examples of what is being tracked and can be useful in evaluating productivity generally.

Data sources for productivity measures also varied widely depending on the specific indices used. Accounting, personnel, production and labor hour data were used as appropriate. Adjustments for inflation and learning curve effects were often made to productivity information, but discounting and quality changes were usually not incorporated.

Validation efforts ranged from virtually no effort to implementing changes in production standards. Usually validation was minimal since internal review mechanisms were not as rigid or strict as would be required for an external audit.

Those with experience in productivity measurement encountered problems of varying degrees in attempting its measurement. Some of the problems reported include:

a. difficulty in isolating cause of improvement above plant level because of many variables

b. qualitative factors influencing productivity difficult to measure

c. difficulty in aggregating data for government accounting on a job-by-job basis while productivity measures require an overall accounting

d. difficulty in quantifying output because of large number and complexity of projects

e. present methods not applicable to white collar area which is 75% of work force

f. difficulty in measuring productivity impacts in other organizational areas

g. timeliness, accuracy, insufficient detail and difficulty in analyzing the data

h. costly to apply, requires computer support, has limited coverage (production operations only)

i. many measurements deal with symptoms, not causes

4. General Comments. Question D.1 of the survey asked:

> If the Government were to offer your company a productivity incentive in a new contract, how would you prefer to have your productivity improvements measured?

Responses included the following:

a. value added/employee

b. cost savings

c. no change in present method being used by company

d. cost reduction relative to a baseline, adjusted for inflation

e. track measurable changes in safety, quality and productivity output in finished good per man-hour of input

f. simple comparison of target cost to actual cost

g. unit production labor hours

h. simple profit rate increases

i. compare new systems to existing systems

j. estimate savings prior to change then increase profit accordingly

k. traditional measures of cost, schedule and performance

l. quality measurement should be used

m. in terms of total factory cost by product.

These responses indicate a desire to keep productivity measurement simple and to base the award on the cost difference between a baseline and achieved cost, adjusted for inflation.

D. SURVEY AND DISCUSSION FINDINGS.

1. Production Cost Visibility.

Production cost visibility and related productivity measurement varied widely among those contractors visited. Some contractors relied primarily upon standard cost accounting systems to yield general profitability information only. Others had sophisticated management information systems (MIS) to capture costs and productivity information in detail at work centers throughout their plants. This allowed tracking a large number and variety of productivity related indices in functional areas in addition to production such as engineering, procurement, and accounting.

2. Direct Costs.

All contractors visited could provide direct labor and material costs through work center tracking. Indirect costs were also available, and overhead rates were calculated and applied to direct costs to get their total cost figures. Unfortunately, direct costs constitute a small and decreasing percentage of total cost, and therefore are becoming less useful as the sole basis for productivity measurement. Indirect costs are substantial and must also be addressed in productivity measurement. For example, direct labor typically amounted to less than 10% of the total cost and is decreasing regularly with the advent of automation and robotics. Figure 3, extracted from the Air Force PACER PRICE program, shows average direct labor rates for spare parts production varying from 8% to 17% depending upon the capital/labor mix.[13] It also shows the tremendous increase in manufacturing overhead and other indirect rates as the capital/labor mix increases from low to high.

3. Productivity and Other Indices.

Productivity information is readily available to all contractors, but some are just beginning to track specific productivity indices. Value added per employee was frequently used as an overall indicator of plant or company productivity; however, no single index is adequate for all contractor purposes. The value added per employee index is useful for contractor purposes in comparisons among plants or companies within an industry.

There was no evidence of a total factor productivity measurement system implemented by the survey respondents, although some were attempting to implement one. Multiple indices were often used; however, they were not integrated as required in a total factor approach. Frequently, other productivity related indices were used for particular purposes in different departments

	HIGH	HIGH-MIDDLE	LOW-MIDDLE	LOW
MANUFACTURING OVERHEAD	343%	231%	189%	112%
OTHER INDIRECT COSTS	36.7%	33.2%	21.9%	14.0%
PROFIT	12.3%	12.8%	13.0%	13.4%
CAS-414	2.1%	1.8%	1.5%	1.2%
ECONOMIC IMPACT RATING	3.161	3.165	2.894	2.977
LEARNING CURVE	98%	96%	92%	84%
DIRECT MATERIAL	27%	24%	24%	21%
DIRECT LABOR	8%	13%	14%	17%
MANUFACTURING HOURLY RATE	12.41	11.48	11.35	10.82

FIGURE 3. PACER PRICE RATE APPLICATION RATES (SOURCE: PROCEEDINGS OF AFLC PACER PRICE CONFERENCE, 3-4 AUG 83)

such as rework hours/direct labor hours, cost of quality/cost of sales, and indirect employees/direct employees. These ratios are not productivity indices per se (using the standard output/input definition) but were useful in measuring and analyzing performance.

4. Tracking Impacts.

Defense contractors know the costs of operating current capital equipment, and they can give a reasonable cost estimate for an investment in new capital equipment. The impact of this new equipment on direct labor and materials is also usually apparent. However, tracking the impact of an investment for productivity improvement in the indirect and overhead areas gets obscured, and these costs usually increase with a decrease in direct costs. For example, programming support costs for a new numerical control milling machine may get buried in the ADP department, or maintenance increases for new robots may get lost since its impact appears negligible. Also, a new automated MIS acquired specifically to provide a degree of cost control not previously possible may also be used for inventory control, financial accounting, and personnel management. Proper allocation among functions is difficult but may be necessary for DOD productivity measurement purposes.

The multiple product, plant and customer environment found at most contractors visited further inhibits accurate cost tracking for productivity measurement. A single plant, single product environment provided <u>relatively</u> easy assessment of productivity improvements for DOD purposes.

5. Follow-up Verifications.

Partly because of the difficulty in tracking the impact of investments in productivity enhancing equipment, the follow-up verification of productivity gains appeared somewhat lax. Although some companies did review an investment at a later date (e.g., one year), the evidence of savings was frequently soft and judgmental. Improvements were accepted intuitively because it was obvious that more goods were produced faster and cheaper at the work center level. Neither the direct nor indirect impact on other areas within the company were readily identifiable or quantifiable.

6. Investment Purposes.

It appeared that investments were mostly for competitive and technological reasons rather than simply for cost reduction. Contractors tended to plan ahead for further contracts, products and capacity and make investments accordingly to improve their long term situation. Contractors also replaced older equipment that could not keep tolerances or required quality levels. Immediate cost improvement was secondary. Sometimes both immediate and long term benefits were realized in an investment, but the long term payoff was primary.

CHAPTER III

PRODUCTIVITY MEASUREMENT SYSTEMS

A. INTRODUCTION.

Although none of the survey respondents has implemented an integrated system for measuring productivity and relating it to profit and/or a contract, five approaches were identified during this initial research as having potential application for IMIP. Most are currently being practiced. They are (1) Common Staffing Study (CSS) developed and used by IBM [16]; (2) Cost Benefit Analysis/Cost Benefit Tracking (CBA/CBT) methodology developed by Price Waterhouse and used at the General Dynamics F-16 plant and other non-defense locations[4]; (3) Multi-factor Productivity Measurement Model (MPMM) offered by the Oklahoma Productivity Center/Oklahoma State University and implemented by numerous commercial firms nationwide[17][1]; (4) Product-Oriented Total Productivity Model (PTPM) developed by Dr. D. Sumanth, University of Miami, and Dr. M. Hassan, Illinois Institute of Technology,[11]; and (5) a generalized "shared savings" approach which analyzes investment cash flow and uses a negotiated return on investment as the basis for reward. These approaches are briefly described in this chapter and evaluated as to their potential for application in DOD. Additional systems to be identified by the investigation of productivity measurement theory and techniques will be further evaluated for potential application for IMIP in a later report.

B. COMMON STAFFING STUDY (CSS).

CSS focuses on indirect work (i.e., overhead manpower) as part of a productivity measurement package addressing both direct and indirect work at

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[1]The MPMM is similar in concept and technique to the APCOMP Performance Measurement System offered by the American Productivity Center. Only MPMM will be described here since it is a representative of this approach to productivity measurement. Both models are commercially available.

IBM. CSS is structured in a heirarchy of 14 model functions, activities for each function, and indicators that relate to the activities. Figure 4 lists the 14 model functions and gives some typical examples of the associated activities and related indicators.

Indicator ratios are calculated for each plant or measurement area and plotted on one chart for comparison purposes. Points varying substantially from a regression line identify plants and areas with improvement potential.

CSS is not a total factor productivity index since it addresses only overhead manpower and not materials, energy, or capital. It does not give a precise measurement or quantitative assessment of performance. CSS does provide a relative measure of productivity among plants and areas and year to year changes for each. It also provides a means of identifying potential areas for improvement.

CSS has potential for IMIP use in addressing the indirect work areas by defense contractors and identifying areas with improvement potential. It would have to be supplemented with some technique for addressing direct work though before it could be tested and implemented in IMIP. The feasibility of that synthesis effort will be determined after additional approaches are evaluated for the final report.

C. COST BENEFIT ANALYSIS/COST BENEFIT TRACKING (CBA/T).

CBA/T is a comprehensive approach to measuring and tracking changes in manufacturing cost and productivity. Among many other features, the cost analysis and tracking are integrated and done concurrently and iteratively. CBA/T differs from conventional cost accounting in that most costs are treated as direct costs as defined below:

TYPICAL EXAMPLES

Model Functions (14)		Activities	Indicator
General Services	(8)	Secretarial Services	Indirect Manpower
Personnel	(15)	Salary Administration	Total Manpower
Finance	(14)	Vendor Billing	Purchasing Dollars
Plant Eng. & Maint.	(10)	Facility Maintenance	Square Feet
I/S & DP	(9)	Computer Operations	Installed Equipment
Production Control	(10)	Production Scheduling	No. Machine/Model Types
Procurement	(4)	Production Buying	Prod. Purch. Dollars
Mfg. Indirect	(4)	Technicians	Direct Manpower
Mfg. Engineering	(16)	Tool Design	Tool Dollars
Quality Assurance	(17)	Inspection	Inplant Direct Work
Industrial Engineering	(10)	Cost Estimating	Value Add Dollars
Materials Distribution	(9)	Warehousing	Transactions
Facility Services	(9)	Safety	Total Manpower
Product Engineer. (WTC)	(5)	Product Support	Part Numbers

FIGURE 4. CSS FUNCTIONS AND EXAMPLE ACTIVITIES AND INDICATORS (FROM IBM BRIEFING PACKAGE GIVEN AT AIA CONFERENCE)

Manufacturing Cost	=	Direct Labor
	+	Direct Material
	+	Machines and Automation
	+	Operational Support
	+	Engineering
	+	Plant and Facilities
	+	Information Systems
	+	Inventory
	+	G&A Support
	+	Finance

CBA/T incorporates a total, top-down factory analysis in a package for effective manufacturing cost management. It is an innovative and comprehensive methodology that refines classical cost classifications while retaining compliance with current DOD cost accounting standards (CAS). Superficial review of the methodology for indirect allocation would cause an appearance of noncompliance with CAS 401 and CAS 402, however a more detailed examination of the accounting technique and costing records discloses no apparent conflict with CAS.

CBA/T is operational at the Generaly Dynamics F-16 plant in Fort Worth, Texas, and is being considered for implementation at additional defense and non-defense manufacturing plants. CBA/T is evolving as an effective technique for managing manufacturing cost and is certainly a prime candidate as a productivity measurement methodology for IMIP.

D. MULTI-FACTOR PRODUCTIVITY MEASUREMENT MODEL (MPMM).

The MPMM is one of a number of approaches incorporating many output and input factors in a productivity measurement that relates directly to profit. The MPMM is a price-weighted, accounting based model that has evolved over time to meet the productivity measurement needs of business managers. Figure 5 gives the matrix structure of the MPMM that provides various indices for the outputs and inputs considered.

	PERIOD 1			PERIOD 2			PRICE WEIGHTED CHANGE RATIOS			COST/REVENUE RATIOS		PRICE WEIGHTED PERFORMANCE INDEXES			TOTAL EFFECTS ON PROFITS		
	QUANTITY, Q_{i1}	PRICE, P_{i1}	VALUE, $(Q_{i1})(P_{i1})$	QUANTITY, Q_{i2}	PRICE, P_{i2}	VALUE, $(Q_{i2})(P_{i2})$	$\frac{Q_2P_1}{Q_1P_1}$	$\frac{Q_2P_2}{Q_2P_1}$	$\frac{Q_2P_2}{Q_1P_1}$	$\frac{\Sigma(Q_{i1})(P_{i1})}{I_{i1}}$	$\frac{\Sigma(Q_{i2})(P_{i2})}{I_{i2}}$	CHANGE IN PRODUCTIVITY (7/7)	CHANGE IN PRICE RECOVERY (17/15)	CHANGE IN PROFITABILITY (11/10)	CHANGE IN PRODUCTIVITY	CHANGE IN PRICE RECOVERY	CHANGE IN PROFITABILITY
OUTPUT(S)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
$O_{i=1...n}$																	
$\sum_{i=1}^{n} O_i$																	
INPUTS(S) I_{ii}																	
LABOR I_{iL}																	
$\sum_{i=1}^{n} I_{iL}$																	
MATERIAL I_{iM}																	
$\sum_{i=1}^{n} I_{iM}$																	
ENERGY I_{iE}																	
$\sum_{i=1}^{n} I_{iE}$																	
INVESTMENT I_{iI}																	
$\sum_{i=1}^{n} I_{iI}$																	
SERVICES I_{iS}																	
$\sum_{i=1}^{n} I_{iS}$																	
ETC																	
TOTAL INPUTS $\sum_{i=1}^{n}$																	
DIFFERENCE																	

FIGURE 5. MULTI FACTOR PRODUCTIVITY MEASUREMENT
OSU/OPC VERSION MPMM-2

One feature of the MPMM is that it identifies profit impacts due to both productivity changes and price recovery (i.e., price/cost changes). Productivity changes are identified by comparing the current accounting period with a previous or base period.

As an accounting based model that directly identifies productivity impacts on profit, the MPMM is an appealing candidate for IMIP. The model has already been implemented in numerous commercial organizations. It appears that MPMM implemention would cause minimal disruption in existing accounting systems and provide the kind of information required for IMIP negotiations. Testing the MPMM in a defense environment is necessary before it could be accepted as an IMIP methodology.

E. PRODUCT-ORIENTED TOTAL PRODUCTIVITY MODEL (PTPM).

PTPM is another approach that aggregates various output and input factors and relates them to profit. A distinction that has potential for IMIP is the product orientation offered. Because of the product breakout provided, considerably more data gathering and record keeping is required for the PTPM than other models like the MPMM and APCOMP Performance Measurement System. The concept of a break-even point for total productivity is also incorporated in the PTPM. Figure 6 shows the matrix structure for the PTPM output and inputs.

The PTPM has features similar to the MPMM but has not had the widespread implementation. It also needs to be tested in a defense environment before it can be accepted as an IMIP methodology.

F. SHARED SAVINGS MODEL.

In addition to the above systems which directly measure contractor productivity, a different, "shared savings" approach was also identified. This generalized approach to productivity measurement attempts to identify produc-

SUMANTH-HASSAN CALCULATIONS SHOW PRODUCTIVITY TRENDS

DATA	Product 1			Product 2		
OUTPUTS	Period 1[1]	Period 2	Period 3	Period 1[1]	Period 2	Period 3
1 Units produced — quantity	2 500	3.020	4 100	2 110	2 285	1 520
$/unit	5 00	8 00	8 50	10 00	12 00	13 00
2 Dividends from securities	700	1 500	1 150	840	1 450	1 800
deflator	1 00	1 10	1 15	1 00	1 10	1 15
3 Interest from bonds — value $	200	300	200	240	330	400
deflator	1 00	1 10	1 15	1 00	1 10	1 15
4 Other income — value $	100	200	150	120	220	300
deflator	1 00	1 10	1 15	1 00	1 10	1 15
INPUTS						
1 Human — total hours worked	500	400	350	400	450	500
average $/h	6 00	6 50	6 70	6 20	6 50	6 80
2 Capital — fixed value ($)[2]	10 000	12 000	15 000	20 000	24 000	28 000
deflator	1 00	1 10	1 18	1 00	1 10	1 18
3 Material — raw material tons	3	5	6	6	4	4 5
$/ton	1 00	1 30	1 80	1 10	1 20	1 30
purchased parts	100	120	105	180	120	150
$/part	1 50	2 00	1 80	1 40	1 50	1 60
4 Energy — oil gallons	25	30	28	31	40	42
$/gallon	1 00	1 15	1 17	1 00	1 15	1 17
coal tons	3	5	7	4	8	3
$/ton	5 00	5 50	6 00	5 00	5 50	6 00
electricity kWh	1 000	1 500	1 600	600	650	700
$/kWh	0 50	0 55	0 60	0 50	0 55	0 60
5 Other — consulting	1 000	4 000	1 500	2 000	4 000	8 000
information	300	350	400	300	400	450
marketing	200	100	150	180	700	300
deflator	1 00	1 15	1 18	1 00	1 15	1 18

[1] Period 1 is the base period 2 Working capital input omitted to simplify illustration and calculations

Data and results are for a fictitious company with two products for a base period and two reporting periods

If a manager had only total company productivity values shown at the right of the results table below he would believe that human and materials productivity were good and that the others needed attention particularly those grouped in the other category The advantage of the Sumanth-Hassan method is that it shows also that Product 2 is the source of the trouble Product 2 factors show poor to very poor productivity in Period 3

RESULTS	Product 1			Product 2			Total Company		
OUTPUTS CONSTANT	Period 1	Period 2	Period 3	Period 1	Period 2	Period 3	Period 1	Period 2	Period 3
1 Units produced	12 500	15 100	20 500	21 000	22 850	15 200	33 600	37 950	35 700
2 Dividends from securities	700	1 364	1 000	840	1 318	1 565	1 540	2 682	2 565
3 Interest from bonds	200	273	174	240	300	348	440	573	522
4 Other income	100	182	130	120	200	261	220	382	391
TOTAL OUTPUT	13 500	16 919	21 804	22 300	24 668	17 374	35 800	41 587	39 178
INPUTS CONSTANT									
1 Human	3 000	2 400	2 100	2 480	2 790	3 100	5 480	4 190	5 200
2 Capital	10 000	10 909	12 711	20 000	21 818	23 729	30 000	32 727	36 440
3 Material	153	185	182	231	172	215	384	357	377
4 Energy	540	797	846	351	395	407	891	1 192	1 253
5 Other	1 500	3 870	1 737	2 480	4 435	7 415	3 980	8 305	9 152
TOTAL INPUT	15 193	18 161	17 556	25 542	29 610	34 866	40 737	46 771	52 422
PRODUCTIVITIES									
Total productivity	0 89	0 93	1 24	0 87	0 83	0 50	0 88	0 89	0 75
Total productivity index	1 00	1 04	1 39	1 00	0 95	0 57	1 00	1 01	0 85
Partial productivity human	4 50	7 05	10 38	8 99	8 84	5 60	6 53	9 93	7 53
Partial productivity index (H)	1 00	1 56	2 31	1 00	0 98	0 62	1 00	1 52	1 15
Partial productivity capital	1 35	1 55	1 72	1 12	1 13	0 73	1 19	1 27	1 08
Partial productivity index (C)	1 00	1 15	1 27	1 00	1 01	0 66	1 00	1 06	0 90
Partial productivity material	88 24	91 45	134 59	96 54	143 42	80 81	93 23	116 48	103 92
Partial productivity index (M)	1 00	1 04	1 53	1 00	1 49	0 84	1 00	1 25	1 11
Partial productivity energy	25 00	21 23	25 77	63 53	62 45	42 69	40 18	34 89	31 27
Partial productivity index (E)	1 00	0 85	1 03	1 00	0 98	0 67	1 00	0 87	0 78
Partial productivity other	9 00	4 37	12 55	8 99	5 56	2 34	8 99	5 01	4 28
Partial productivity index (O)	1 00	0 49	1 39	1 00	0 62	0 26	1 00	0 56	0 48

FIGURE 6. PRODUCTIVITY MATRIX FOR PRODUCT-ORIENTED TOTAL PRODUCTIVITY MODEL (SOURCE: BIRCHFIELD, J.R. "HOW TO GET A HANDLE ON PRODUCTIVITY," MANUFACTURING PRODUCTIVITY FRONTIERS, IIT, CHICAGO, IL 60616 JUNE 28, 1982)

tivity-enhancing investments by the contractors and share the resulting acquisition cost savings. DOD receives a reduced acquisition cost, and the contractor earns a desired return on investment through increased profits from the savings. Productivity changes are not specifically addressed using shared savings. The Discounted Cash Flow Shared Saving Model, proposed by the Logistics Management Institute, is one model for analyzing shared savings investments.[7]

The shared services approach is compatible with the desires expressed by survey respondents to simply base productivity rewards on the difference between a baseline and the lower acquisition price. It has been used as part of the business arrangement negotiated between the Air Force and General Dynamics for F-16 production. A shortcoming is that productivity measurements are ignored. This means the government would have to negotiate without access to specific productivity information. Further evaluation of the shared savings approach is deferred until the final report.

CHAPTER IV

SUMMARY AND RECOMMENDATIONS

A. SUMMARY.

1. Productivity Measurement Practices.

Research conducted to date has identified current contractor productivity measurement practices. Contractors responding to a survey of measurement practices ranked profitability most important on a list of organizational performance evaluation factors. If used at all, productivity was usually ranked fifth, after profitability, effectiveness, quality and efficiency.

Problems encountered by the contractors measuring their productivity were usually due to the complexities of quantifying and relating the various input and output factors involved. Also, meaningful indices were not readily available to identify production productivity impacts on organizational areas other than production.

The respondents indicated a desire to keep any proposed productivity measurement system simple and to base the reward for productivity gains on the cost difference between a baseline and achieved cost, adjusted for inflation. This is basically the way DOD currently attempts productivity measurement and its associated profit reward in the weighted guidelines methodology, but it has not been successfully implemented as currently structured.

There was no evidence of a total factor productivity measurement system implemented by the survey respondents; although some attempts were being made to develop such. Multiple indices were often used; however, they were not integrated as required in a total factor approach. The most popular productivity or performance related indices being tracked by defense contractors were value added/employee and a comparison of standard hours to actual hours for work performed. Some confusion existed as to whether an index was a productivity measurement (i.e., output/input) or some other performance measurement.

Production cost visibility varied widely among the contractors visited, but all could provide direct labor and material costs through work center tracking. Unfortunately, direct costs constitute a small and decreasing percentage of total cost, and therefore are becoming less useful as the sole basis for productivity measurement. Indirect costs are substantial and must also be addressed.

Tracking the impact of an investment for productivity improvement in the indirect areas gets obscured, and these areas frequently increase with a decrease in direct cost. The multiple product, plant and customer environment found at most contractors visited further inhibits accurate cost tracking for productivity measurement. Partly because of the difficulty in tracking the impact of investments in productivity enhancing equipment, the follow-up verification of productivity gains was somewhat lax, especially in the indirect areas.

From the discussions with the contractors visited, it appeared that investments were mostly for competitive and technological reasons rather than simply for cost reduction on the current contract. Contractors tended to plan ahead to other contracts and products and make investments accordingly to improve their long run situation.

2. Productivity Measurement Systems.

Although no integrated total factor productivity measurement system has been implemented by survey respondents, a few approaches to productivity measurement were identified during this initial research as having potential application for IMIP. They are:

a. Common Staffing Study (CSS)

b. Cost Benefit Analysis/Tracking (CBAT)

c. Multi-Factor Productivity Measurement Model (MPMM)

d. Product-Oriented Total Productivity Model (PTPM)

e. Shared Savings.

The Common Staffing Study (CSS) approach to productivity measurement was developed and implemented by IBM to address overhead manpower for productivity comparisons among plants. The Cost Benefit Analysis/Cost Benefit Tracking (CBA/T) methodology offered by Price-Waterhouse is a comprehensive approach to measuring and tracking changes in manufacturing cost and productivity, but it challenges classical cost classifications. The Multi-Factor Productivity Model (MPMM) is representative of models which are price-weighted and accounting based. These models include various input and output factors and relate them directly to profit. The Product-Oriented Total Productivity Measurement Model (PTPM) is similar to the MPMM but provides productivity indicators by product. The "shared savings" models do not address specific productivity indices or improvements but base ROI rewards to the contractor upon the differences between a baseline and lower acquisition cost resulting from productivity-enhancing investments.

B. <u>RECOMMENDATIONS</u>.

This study should continue as planned. Research to date has provided useful insights for IMIP by identifying current productivity measurement practices by defense contractors. Progress shown thus far and the substantial potential benefits remaining warrant project continuation.

In addition to ascertaining current productivity measurement practices, initial research has identified several productivity measurement systems that have potential use in IMIP. These systems, and others to be described in the investigation of productivity measurement theory and techniques, provide useful candidates that should be tested.

The most prominent at this juncture because of its comprehensive, integrated approach to measuring manufacturing cost and productivity is the Cost Benefit Analysis/Cost Benefit Tracking (CBA/T) methodology. Current applications of CBA/T in DOD could serve as tests and should be pursued further before widespread application for IMIP can be made.

Plans should also be made by this study team to test both the Multifactor Productivity Measurement Model (MPMM) and the Product-Oriented Total Productivity Model (PTPM). They have potential for IMIP use since they are accounting based models that relate productivity directly to profit but must first be tested in a defense environment.

Additional methodologies will be recommended for testing, if warranted, following the evaluation of those identified during the investigation of productivity measurement theory and techniques.

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APPENDIX A

CONTRACTOR PRODUCTIVITY MEASUREMENT SURVEY

NATIONAL SECURITY INDUSTRIAL ASSOCIATION
National Headquarters
1015 15th Street, N.W.
Suite 901
Washington, D.C. 20005
Telephone (202) 393-3620

4 March 1983

In support of DoD efforts to encourage improved defense contractor productivity, the Army Procurement Research Office (APRO) is examining practical ways of measuring productivity. This letter provides you an opportunity to participate in an effort that will mutually benefit both industry and DoD.

In this regard, on 4 November 1982 the Defense Department announced the test of an Industrial Modernization Incentives Program (IMIP) designed to encourage contractors to make capital investments that will improve their industrial productivity. The incentives to be tested are shared savings rewards, contractor investment (termination) protection, and others which may be appropriate. Development of a practical method of measuring contractor productivity is of importance if certain incentive structures are to be used.

APRO is seeking information about productivity measurement methodologies currently employed by defense contractors, and NSIA has agreed to participate in a survey of its members. While the survey can be completed anonymously, we suggest you identify yourselves for follow-up discussions. Your cooperation in completing and returning this survey to NSIA by 20 April 1983, is solicited.

Sincerely,

L. H. Bosshard
Committee Executive
Procurement Committee

LHB/md
enc.

PRODUCTIVITY MEASUREMENT SURVEY

The Army Procurement Research Office (APRO) is seeking information describing productivity measurement methodologies used by defense contractors. APRO does not want data on actual performance or goals achieved or other potentially sensitive information. Although the survey can be completed anonymously, contractor identification is encouraged in Section E for possible follow-up discussions. Some of the questions require responses on separate paper.

A. GENERAL INFORMATION:

1. Indicate your predominant commodity markets in order of relative importance to your company, (e.g., 1, 2, 3 . . .)

_____ (a) Aircraft

_____ (b) Missile and Space Systems

_____ (c) Ships

_____ (d) Tank-Automotive

_____ (e) Weapons

_____ (f) Ammunition

_____ (g) Electronics and Communication Equipment

_____ (h) Other (Specify)

2. Are you currently involved as a prime or subcontractor on a major weapon system? _____ No _____ Yes
_____ Prime _____ Subcontractor _____ Both

3. State the approximate dollar value of your defense contracts during your last accounting period. ______ Amount ______ Period

4. With which military service did you contract in the last business year? If more than one, indicate the predominant service with a P and check others.

_____ (a) Army

_____ (b) Navy (Marines)

_____ (c) Air Force

_____ (d) Defense Agencies (e.g., DLA, DARPA, etc.)

B. PERFORMANCE EVALUATION (at profit center level or above):

1. Which of the following factors do you use to measure organizational performance within your company? (Indicate order of relative importance to your company, e.g., 1, 2, 3 . . .)

_____ (a) Effectiveness (i.e., accomplishing the right goals or objectives considering timeliness, quantity, and quality)

_____ (b) Efficiency (i.e., ratio of resources expected to be consumed on goal achievement to resources actually consumed)

_____ (c) Quality (i.e., conformance to specifications)

_____ (d) Profitability (i.e., comparison of revenues to costs)

_____ (e) Productivity (i.e., ratio of output to input)

_____ (f) Quality of Working Life (i.e., personnel response to living and working in organization)

_____ (g) Innovation (i.e., introducing new ideas, processes, or products)

_____ (h) Other - (Please specify) ______________________________

2. Describe the specific measures used to evaluate the performance factors identified above. (e.g., for profitability - return on assets employed, return on investment, etc.; for quality - average quality level, number of rework hours, etc.).

3. Describe any problems or shortcomings encountered in using your measures (except for the productivity measure which is to be described in Section C).

4. If you are required to report any of the above or similar measures on a defense contract, please specify.

IF PRODUCTIVITY IS BEING MEASURED, COMPLETE SECTION C, OTHERWISE SKIP TO SECTION D.

C. PRODUCTIVITY MEASUREMENT:

1. For the productivity measures identified in question B.2, specify the level within your company to which each measure applies - program, shop, department, plant, firm, etc.

2. Briefly describe the data sources used to measure and track achievements for each productivity measure.

3. Describe your measurement techniques, including any data adjustments, used for each productivity measure. Data adjustments include such items as inflation, discounting, quantity or quality changes, and learning curve effect.

4. Describe any validation or follow-up actions required to be taken subsequent to implementation of proposed productivity improvements.

5. What problems or shortcomings are encountered in using your productivity measures?

6. Would you be willing to discuss additional details of your productivity measurement methodology with DOD if needed? _____ Yes _____ No (If yes, please complete Section E).

7. If documentation is available describing your productivity measurement procedures, please send a copy to

US Army Materiel Systems Analysis Activity
US Army Procurement Research Office
ATTN: DRXSY-PRO (Project 83-01)
Fort Lee, Virginia 23801

D. COMMENTS:

1. If the Government were to offer your company a productivity incentive in a new contract, how would you prefer to have your productivity improvements measured?

2. Additional information or comments pertinent to this survey would be appreciated. Questions should be referred to either Mr. Monte Norton or Mr. Wayne Zabel, APRO, telephone (804) 734-3896.

E. ORGANIZATION DESCRIPTION (Optional):

1. Company Name and Address:

2. Point of Contact (Name and Telephone):

APPENDIX B

EXAMPLE PERFORMANCE RATIOS USED TO MEASURE OR

EVALUATE PRODUCTIVITY

EXAMPLES OF PRODUCTIVITY MEASUREMENTS

PRODUCTION/PRODUCTION PROFIT CENTER MEASUREMENTS

$\frac{\text{DIRECT HOURS}}{\text{STANDARD HOURS}}$	$\frac{\text{SCRAP COSTS}}{\text{L.B.M ADDITIONS}}$	$\frac{\text{INVENTORY SHORTAGE}}{\text{INVENTORY ADDITIONS}}$
$\frac{\text{EARNED HOURS}}{\text{DIRECT HOURS}}$	$\frac{\text{L.B.M \& SUPPORT COSTS}}{\text{NO. OF UNITS PRODUCED}}$	$\frac{\text{TOTAL PRODUCTION HOURS}}{\text{DIRECT EARNED HOURS}}$
$\frac{\text{INDIRECT HOURS}}{\text{DIRECT HOURS}}$	$\frac{\text{FIXED PRICE COST OF SALES}}{\text{GROSS NET INVENTORY}}$	$\frac{\text{DELINQUENT UNITS X SELLING PRICE}}{\text{AVERAGE DAILY SALES}}$
$\frac{\text{SALVAGE HOURS}}{\text{DIRECT HOURS}}$	$\frac{\text{SALES/VA SALES}}{\text{DIRECT HEADCOUNT}}$	$\frac{\text{PRODUCTION SUPPORT COSTS}}{\text{PRODUCTION L.B.M COSTS}}$
$\frac{\text{SET-UP HOURS}}{\text{EARNED HOURS}}$	$\frac{\text{SALES/VA SALES}}{\text{TOTAL HEADCOUNT}}$	$\frac{\text{INDIRECT HEADCOUNT}}{\text{DIRECT HEADCOUNT}}$
$\frac{\text{DIRECT LABOR \\$}}{\text{STANDARD HOURS}}$	$\frac{\text{PRODUCT BUILD \& SUPPORT HOURS}}{\text{EQUIVALENT UNITS PRODUCED}}$	$\frac{\text{PRODUCTION HOURLY HEADCOUNT}}{\text{PRODUCTION CONTROL HEADCOUNT}}$
$\frac{\text{NO. OF UNITS ACCEPTED}}{\text{NO. OF UNITS INSPECTED}}$	$\frac{\text{CUSTOMER ACCEPTED LOTS}}{\text{LOTS SUBMITTED}}$	$\frac{\text{PRODUCTION HOURLY HEADCOUNT}}{\text{PRODUCTION ENGINEERING HEADCOUNT}}$
$\frac{\text{WAIT TIME HOURS}}{\text{DIRECT LABOR HOURS}}$	$\frac{\text{WARRANTY REPAIR COSTS}}{\text{SALES}}$	$\frac{\text{NO. OF DEFECTS}}{\text{NO. OF UNITS INSPECTED}}$
$\frac{\text{UNITS SCHEDULED}}{\text{UNITS PRODUCED}}$	$\frac{\text{SALES/VA SALES}}{\text{INDIRECT HEADCOUNT}}$	$\frac{\text{HRS ON LABOR TICKET REJECTS}}{\text{TOTAL HOURS REPORTED}}$
$\frac{\text{COMPLETE KITS ISSUED}}{\text{TOTAL KITS ISSUED}}$	$\frac{\text{COST OF QUALITY}}{\text{COST OF SALES}}$	$\frac{\text{ACTUAL BURDEN RATE}}{\text{PLANNED BURDEN}}$
	$\frac{\text{PBIT}}{\text{EMPLOYEES}}$	

ENGINEERING/ENGINEERING PROFIT CENTER MEASUREMENTS

$\frac{\text{DIRECT LABOR}}{\text{TOTAL TIME REPORTING LABOR}}$	$\frac{\text{PROJECTED UNIT BUILD COST}}{\text{TARGET UNIT BUILD COST}}$	$\frac{\text{NO. OF KEY PERFORMANCE SPECS MET}}{\text{TOTAL NO. OF KEY PERFORMANCE SPECS}}$
$\frac{\text{SALES/VA SALES}}{\text{TIME REPORTING HEADCOUNT}}$	$\frac{\text{PRODUCTION SUPPORT COSTS}}{\text{PRODUCTION L.B.M COSTS}}$	$\frac{\text{NO. OF PROGRAMS WHERE PVWA ACTUAL}}{\text{NO. OF PROGRAMS}}$
$\frac{\text{SALES/VA SALES}}{\text{INDIRECT HEADCOUNT}}$	$\frac{\text{NO. OF ECO's}}{\text{NO. OF DRAWINGS}}$	$\frac{\text{COUNTER PRODUCTIVE HOURS}}{\text{TOTAL ENGINEERING HOURS}}$
$\frac{\text{SALES/VA SALES}}{\text{TOTAL HEADCOUNT}}$	$\frac{\text{HRS ON REJECTED TIME REPORTS}}{\text{TOTAL HRS REPORTED}}$	$\frac{\text{NO. OF DRAWINGS}}{\text{DRAFTING HEADCOUNT}}$
$\frac{\text{NO. OF SOFTWARE INSTRUCTIONS}}{\text{NO. OF SOFTWARE ENGINEERS}}$	$\frac{\text{PROJECTS WITH PLANS}}{\text{TOTAL PROJECTS}}$	$\frac{\text{NO. OF ECO's}}{\text{NO. OF ENGINEERS}}$
$\frac{\text{COST TO PREPARE DRAWINGS}}{\text{NO. OF DRAWINGS PRODUCED}}$	$\frac{\text{PROJECTS OVERRUN}}{\text{TOTAL PROJECTS}}$	$\frac{\text{BID HOURS}}{\text{ESTIMATED HOURS}}$
$\frac{\text{PROD BUILD HRS ON LAYOUTS}}{\text{PROD BUILD HRS}}$	$\frac{\text{PROJECTS OVERRUN \\$}}{\text{TOTAL PROJECT \\$}}$	$\frac{\text{NEGOTIATED HOURS}}{\text{BID HOURS}}$
$\frac{\text{PBIT}}{\text{EMPLOYEES}}$	$\frac{\text{CAD HOURS USAGE}}{\text{CAD HOURS AVAILABLE}}$	$\frac{\text{PLANNED COST ALL PROGRAMS}}{\text{ACTUAL COST ALL PROGRAMS}}$
$\frac{\text{BCWP BCWP}}{\text{BSWS ACWP}}$	$\frac{\text{ACTUAL BURDEN RATE}}{\text{PLANNED BURDEN RATE}}$	$\frac{\text{FACTORY COSTS}}{\text{PRODUCTION ENGINEERING COSTS}}$
	$\frac{\text{MILESTONES COMPLETED I-T-D}}{\text{MILESTONES SCHEDULED I-T-D}}$	

QUALITY DEPARTMENT MEASUREMENTS

$\frac{\text{QUALITY DEPT. HOURS}}{\text{PRODUCTION HOURS}}$	$\frac{\text{MATERIAL LOTS INSPECTED}}{\text{RECEIVING INSPECTION HEADCOUNT}}$	$\frac{\text{ERRORS IN DATA COLLECTION}}{\text{VOLUME OF DATA COLLECTED}}$
$\frac{\text{QUALITY INDIRECT HOURS}}{\text{TOTAL QUALITY HOURS}}$	$\frac{\text{TOTAL OPERATING HEADCOUNT}}{\text{QUALITY DEPT. HEADCOUNT}}$	$\frac{\text{ACTUAL BURDEN RATE}}{\text{PLANNED BURDEN RATE}}$
$\frac{\text{EARNED HOURS}}{\text{DIRECT HOURS}}$	$\frac{\text{OPERATIONS BUDGET}}{\text{QUALITY DEPT. BUDGET}}$	$\frac{\text{PREVENTION COSTS}}{\text{COST OF QUALITY}}$
$\frac{\text{COST OF QUALITY}}{\text{COST OF SALES}}$	$\frac{\text{PRODUCTION EARNED HOURS}}{\text{QUALITY ENG. SUPPORT HOURS}}$	$\frac{\text{APPRAISAL COSTS}}{\text{COST OF QUALITY}}$
$\frac{\text{SALES/VA SALES}}{\text{PRODUCT ASSURANCE HEADCOUNT}}$	$\frac{\text{QE SUPPORT COSTS}}{\text{PRODUCTION L.B.M COSTS}}$	$\frac{\text{FAILURE COSTS}}{\text{COST OF QUALITY}}$
$\frac{\text{TOTAL RECEIVING INSP. HOURS}}{\text{LOTS RECEIVED}}$	$\frac{\text{ERRORS ON INSPECTION PROCEDURES}}{\text{INSPECTION PROCEDURES ISSUED}}$	

PROCUREMENT DEPARTMENT MEASUREMENTS

$\frac{\text{PURCHASE ORDER ERRORS}}{\text{PURCHASE ORDERS AUDITED}}$	$\frac{\text{PURCHASING DEPT. BUDGET}}{\text{NO. OF PO's PLACED}}$	$\frac{\text{TOTAL OPERATIONS HEADCOUNT}}{\text{PURCHASING DEPT. HEADCOUNT}}$
$\frac{\text{ESTIMATED SAVINGS ON ORDERS PLACED}}{\text{DOLLAR VALUE OF ORDERS PLACED}}$	$\frac{\text{\$ AMOUNT OF PURCHASES}}{\text{PURCHASING DEPT. HEADCOUNT}}$	$\frac{\text{SALES/VA SALES}}{\text{PROCUREMENT DEPT. HEADCOUNT}}$
$\frac{\text{MATERIAL PROPOSAL RECORDS RECEIVED}}{\text{MATERIAL PROPOSAL RECORDS COMPLETED}}$	$\frac{\text{LOTS RECEIVED ON TIME}}{\text{TOTAL LOTS RECEIVED}}$	$\frac{\text{\$ AMOUNT OF PURCHASES}}{\text{PURCHASING DEPT. BUDGET}}$
$\frac{\text{INCOMING MATERIAL LOTS ACCEPTED}}{\text{INCOMING MATERIAL LOTS}}$	$\frac{\text{NO. OF PO's PLACED}}{\text{PURCHASING DEPT. HEADCOUNT}}$	$\frac{\text{NO. OF MPR's RETURNED ON TIME}}{\text{NO. OF MPR's RETURNED}}$

FINANCE DEPARTMENT MEASUREMENTS

$\frac{\text{TRADE BILLED RECEIVABLE \$}}{\text{AVG TRADE BILLED SALES/DAY}}$	$\frac{\text{NO. OF PRICING PROPOSALS}}{\text{NO. OF PRICING PEOPLE}}$	$\frac{\text{INCOMPLETE COST STANDARD}}{\text{TOTAL COST STANDARDS}}$
$\frac{\text{INVOICES PROCESSED X STANDARD}}{\text{INVOICING HOURS}}$	$\frac{\text{OPERATIONS BUDGET}}{\text{FINANCE DEPT. BUDGET}}$	$\frac{\text{FINANCE DEPT. BUDGET}}{\text{SALES}}$
$\frac{\text{DISBURSEMENTS AUDIT FUNCTIONS X STANDA}}{\text{DISBURSEMENT AUDIT HOURS}}$	$\frac{\text{SALES/VA SALES}}{\text{FINANCE PERSONNEL}}$	$\frac{\text{\$ VALUE OF PRICING PROPOSALS}}{\text{NO. OF PRICING PEOPLE}}$
$\frac{\text{TOTAL OPERATIONS PERSONNEL}}{\text{FINANCE PERSONNEL}}$	$\frac{\text{NO. OF DD250 ERRORS}}{\text{TOTAL DD250's PROCESSED}}$	$\frac{\text{INVOICING ERRORS}}{\text{INVOICES PROCESSED}}$
	$\frac{\text{RECEIVABLES OVER 60 DAYS}}{\text{TOTAL RECEIVABLES}}$	

$$\frac{\text{DISBURSEMENTS AUDIT FUNCTIONS X STANDARD}}{\text{DISBURSENEBT AUDIT HOURS}}$$

COMMUNICATIONS DEPARTMENT MEASUREMENTS

REPRODUCTION COSTS / NO. OF PAGES PRODUCED	SALES/VA SALES / COMMUNICATIONS DEPT. HEADCOUNT	COST OF VIEWGRAPH CHANGES / TOTAL GRAPHICS COST
VIEWGRAPHS REDONE / TOTAL VIEWGRAPHS PRODUCED	OPERATIONS HEADCOUNT / COMMUNICATIONS DEPT. HEADCOUNT	

LOGISTICS DEPARTMENT MEASUREMENTS

NO. OF PROGRAMS WHERE PVWA ACTUALS / NO. OF PROGRAMS	ORDERS FOR LOGISTICS SERVICES / TOTAL ORDERS
AVERAGE MAINTENANCE DOWN TIME OF GYROS / 75 DAYS	AVERAGE GRADE LEVEL OF FLD ENGRS / AVERAGE GRADE LEVEL OF IDEAL WORK FORCE
QTY OF SPARES DELIVERED / QTY OF SPARES TO BE DELIVERED PER CONTRACT	SALES/VA SALES / LOGISTICS HEADCOUNT
MAINTENANCE COSTS/FLT. HR. UNITS IN-HOUSE / $22 UNIT / 0.333	SPECIFIC PROG. LOGISTICS ORDERS / SPECIFIC PROG. NON-LOGISTICS ORDERS / 0.20

GENERAL/MISCELLANEOUS MEASUREMENTS

ACTUAL HRS/$ / ESTIMATED HRS/$	MAINTENANCE ORDERS WITHIN ESTIMATE / TOTAL MAINTENANCE ORDERS	HEADCOUNT / NO. OF SECRETARIES
DIRECT HEADCOUNT / INDIRECT HEADCOUNT	UNPLANNED ABSENT HOURS / TOTAL HOURS	NO. OF PEOPLE IN QC TEAMS / TOTAL EMPLOYEES
OPERATIONS HEADCOUNT / DEPARTMENT HEADCOUNT	BACKLOG HRS ON MAINTENANCE WORK ORD / MAINTENANCE HEADCOUNT	SALES / ASSETS
OPERATIONS SALES/VA SALES / DEPARTMENT HEADCOUNT	NON-PRODUCTIVE TIME / TOTAL TIME AVAILABLE	PROFIT / EMPLOYEES
BUILDING SQ. FOOTAGE / MAINTENANCE CLEANING PERSONNEL	DEPARTMENT COSTS / DEPARTMENT BUDGETED COSTS	ASSETS / EMPLOYEES

BACKLOG HRS ON MAINTENANCE WORK ORDERS / MAINTENANCE HEADCOUNT

MAINTENANCE COSTS/FLT. HR. / $22

UNITS IN-HOUSE / UNIT / 0.333

SERVICE ENGINEERING DEPARTMENT MEASUREMENTS

$\frac{\text{PROPOSALS WON}}{\text{PROPOSALS SUBMITTED}}$	$\frac{\text{OPERATIONS BUDGET}}{\text{SERVICE ENG. BUDGET}}$	$\frac{\text{NO. OF ACTIVE CONTRACTS}}{\text{NO. OF CONTRACT ADMINISTRATORS}}$
$\frac{\text{\$ ORDERS RECEIVED Y-T-D}}{\text{\$ ORDERS PLANNED Y-T-D}}$	$\frac{\text{\$ DELINQUENT DELIVERIES}}{\text{AVERAGE DAILY SALES}}$	$\frac{\text{FP ORDERS WITH PROGRESS PAYMENTS}}{\text{TOTAL NO. OF FP ORDERS}}$
$\frac{\text{\$ ORDERS RECEIVED - MONTH/YEAR}}{\text{NO. OF MARKETEERS/CONTRACT ADMIN.}}$	$\frac{\text{NO. OF PROPOSALS}}{\text{NO. OF MARKETING REPS.}}$	$\frac{\text{SALES PROPOSAL \$}}{\text{\$ ORDERS RECEIVED}}$
$\frac{\text{TOTAL OPERATIONS PERSONNEL}}{\text{SERVICE ENGINEERING PERSONNEL}}$	$\frac{\text{\$ ORDERS RECEIVED}}{\text{SERVICE ENG. BUDGET}}$	$\frac{\text{SERVICE ENG. BUDGET}}{\text{OPERATIONS SALES}}$
$\frac{\text{SALES/VA SALES}}{\text{SERVICE ENGINEERING HEADCOUNT}}$	$\frac{\text{NO. OF DD250 ERRORS}}{\text{TOTAL DD250's PROCESSED}}$	

EMPLOYEE RELATIONS DEPARTMENT

$\frac{\text{CHANGE NOTICES PROCESSED}}{\text{NO. OF COMPENSATION CLERICALS}}$	$\frac{\text{NO. OF PEOPLE INTERVIEWED \& HIRED}}{\text{NO. OF PEOPLE INTERVIEWED}}$	$\frac{\text{WORKERS COMPENSATION HOURS}}{\text{TOTAL HOURS WORKED}}$
$\frac{\text{RECRUITMENT COSTS}}{\text{NO. OF PEOPLE HIRED}}$	$\frac{\text{OPERATIONS SUPPORT}}{\text{EMPLOYEE RELATIONS BUDGET}}$	$\frac{\text{OFFERS MADE}}{\text{OFFERS ACCEPTED}}$
$\frac{\text{SALES/VA SALES}}{\text{EMPLOYEE RELATIONS HEADCOUNT}}$	$\frac{\text{ELAPSED TIME OF UNPROCESSED ECR's}}{\text{NO. OF UNPROCESSED ECR's}}$	$\frac{\text{EMPLOYEES TERMINATING}}{\text{TOTAL EMPLOYEES}}$
$\frac{\text{TOTAL OPERATIONS HEADCOUNT}}{\text{EMPLOYEE RELATIONS HEADCOUNT}}$	$\frac{\text{INSURANCE CLAIMS PROCESSED}}{\text{NO. OF INSURANCE CLAIM CLERKS}}$	
$\frac{\text{NO. OF CHANGE NOTICE ERRORS}}{\text{TOTAL CHANGE NOTICES}}$	$\frac{\text{LOST TIME FOR INJURIES}}{\text{TOTAL HOURS WORKED}}$	

INFORMATION SYSTEMS DEPARTMENT

$\frac{\text{OUTPUT DISTRIBUTED ON-TIME}}{\text{TOTAL OUTPUT DISTRIBUTED}}$	$\frac{\text{KEYPUNCH EARNED HOURS}}{\text{KEYPUNCH ACTUAL HOURS}}$	$\frac{\text{OPERATIONS BUDGET}}{\text{IS BUDGET}}$
$\frac{\text{HARDWARE UP TIME}}{\text{TOTAL HARDWARE TIME}}$	$\frac{\text{JOBS COMPLETED}}{\text{JOBS SCHEDULED}}$	$\frac{\text{USER COMPLAINTS}}{\text{HOURS OF USAGE}}$
$\frac{\text{OUT OF SERVICE TERMINALS}}{\text{TOTAL NO. OF TERMINALS}}$	$\frac{\text{SALES/VA SALES}}{\text{IS HEADCOUNT}}$	$\frac{\text{PROJ. ESTIMATED DEVELOPMENT COST}}{\text{PROJ. ACTUAL DEVELOPMENT COST}}$
$\frac{\text{TROUBLE CALLS RECEIVED}}{\text{UNIT OF TIME (WEEK, MO. ETC.)}}$	$\frac{\text{TOTAL OPERATIONS HEADCOUNT}}{\text{IS HEADCOUNT}}$	$\frac{\text{MRP/HMS PERFORMANCE/USAGE}}{\text{VARIOUS MRP/HMS CRITERIA}}$

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The project objectives of this tri-service effort are to develop and test defense contractor productivity measurement methodologies. This interim report describes the results of a survey of contractor systems identified to date. Several productivity measurement systems are identified as having potential application to DOD Industrial Modernization Incentives Program (IMIP).

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